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centage is highest in the white fleshed varieties. It appears also that the per cent of acidity is greater in varieties having dark colored flesh. In the pear the percentage called "sub-acid" is decidedly greatest in the white fleshed varieties. This may at first seem contradictory to my hypothesis. It should not be forgotten, however, that in the apple and pear a mild acidity greatly improves the flavor, and hence this apparent exception is possibly the result of selection.

In the plum no varieties are said to have white flesh. I find, however, that in five varieties in which the flesh is called "amber color," and three called "pale green," none are called acid; while in fifty-nine varieties called "yellow," five have some acid, in thirty-three called "greenish yellow," three are called acid, in twenty called "greenish," five are called acid, and in nine called "greenish yellow," three are called acid.

In the other fruits and vegetables I have not found sufficiently accurate descriptions to permit me to judge whether the hypothesis holds or not.

If further investigation should discover sufficient evidence in this direction to establish a law, this law will have an important practical application in the amelioration of fruits and vegetables.

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GROWTH, ITS CONDITIONS AND VARIATIONS.

BY CHARLES MORRIS.

(Continued from page 1101, November number.)

FAR back in the history of life we reach a period in which crustaceans and mollusks seem to have been the lords of the earth. During the greater part of the Palæozoic age the ocean invertebrates were dominant, they grew to great size, developed rapidly in functional ability, and swept the seas of their stores of food. We know little of the struggle which then took place between the various invertebrate sub-kingdoms, or of their probably successive rise to supremacy. Nor can we trace the struggle between the members of each sub-kingdom. So far as evidence goes the cephalopods would seem to have been contemporaneous in origin with humbler representatives of their race and of other races. But this is doubtless an illusion produced by an undue crowding together of the geological tablets.

This invertebrate era was succeeded by the earliest stage of

the vertebrate. The Palæozoic fishes appeared. At first they must have been inferior in size, weapons and food-getting power to their invertebrate rivals, who so long had ruled the sea. But their superiority of organization quickly told. They came into competition with their former superiors, and soon progressed beyond them, gaining massive armor of defence and strong reptilian teeth for attack. The empire of the seas had passed into new hands. These great ganoid and dipnoid fishes increased in size and strength, the invertebrate wave sank before them, and the lordship of the ocean became their own. The result was the same that has appeared in all such cases. They not only grew great in bulk, from the abundance of their food supply, but they varied with the greatest rapidity in specific character, assuming every variety of adaptation to their variety of food. This rapid specific variation of each type of life immediately after gaining the supremacy over preceding dominant types, is a fact which may be traced throughout the geological age, and indicates that variation in form and habits, while slow under ordinary conditions, may be extremely rapid under such specially favoring circumstances.[1]

These early dominant fish, while superior in power to all preceding animals, were inferior to those that succeeded them in the fact that they trusted for defence to massive armor instead of to speed. In the whole history of life trust to armor has been an inferior characteristic, the armored animals have tended to grow more sluggish, and in most cases to assume a sedentary life, while all steps of higher development have been attained by the less weighted and swifter moving animals. Such is the story of ocean life. As we enter the Mesozoic age unarmored reptiles succeed to the armored ganoids and quickly take from them the empire of the seas. The duplex characteristics of the Palæozoic fishes seem to divide, developing in one direction into the more efficient reptiles, and in the other into the teleostean fishes, which are well adapted to obtain food from the humbler life of the sea. The only continuous representative of the earlier dominant fishes is the shark, which had cast off its excess weight and thus became able to contest the field with the swimming reptiles, and even to survive them. But the immense size attained by these

[1] For the details of this hypothesis see paper by Alpheus Hyatt, *Science*, Nos. 52 and 53.

reptiles, and their rapid variation in specific character, indicate their superiority over all the remaining ocean life of their period, the abundant food which they obtained with little effort, and the variety in organization and methods of escape of this food, which necessitated accordant variations in its foes.

While these revolutions were taking place in the empire of the seas, life had invaded the land. Insects were the first animal inhabitants of the land, so far as evidence goes. They gained no extreme size, perhaps through a paucity of food supply and organic inefficiency. Yet land articulates seem to have rapidly increased in variety, since spiders, scorpions and myriapods appear almost contemporaneously with insects. At the same period, or shortly afterwards, ocean vertebrates invaded the land. The character of their invasion singularly resembles that of the articulates. The latter were obviously derived from water articulates, since the first known forms belong to those families which pass their larval period in the water. In like manner the earliest land vertebrates were batrachians, which in their larval state are water animals. These creatures seem to have found a free field and abundant food, and to have multiplied and varied with great rapidity, while some of them attained great bulk despite their imperfect organization. Cope gives a list of thirty-nine genera and about a hundred species of Carboniferous batrachians, which indicates that the full degree of specific variation was very great. In fact they seem to have had the world of the land to themselves, with nothing but the imperfection of their organization to hinder their obtaining superabundant food with little exertion, and thus growing to immense size.

This age of batrachian dominance was succeeded by one in which the wave of batrachian life declined, while huge land animals took their place on the throne of the empire of life. The batrachians were unfitted to compete with reptiles in the struggle for food, and were obliged to content themselves with lesser supplies, so that they quickly diminished in size before the onset of their strong competitors. Very probably personal assault from these new-comers, as they grew stronger and able to cope with the batrachians, hastened the decline of the latter, and drove them down into the humbler fields of life.

And now came a new life era. The land reptiles increased in number and variety with the seeming suddenness of all preceding

dominant forms, and grew in many instances to enormous bulk, far exceeding anything previously known among the inhabitants of the land. Step by step the animal world was learning the art of food taking. The lesson was slowly learned. The two energies of escape and pursuit kept pace in development, each forcing the other upwards. The continued effort at escape or defence must have yielded steadily greater efficiency and variety. This in its turn rendered necessary the development of new and more efficient weapons and methods of assault. Thus has life been pushed ever upward, the Carnivora forcing their living food to superior development, and the food animals exerting a like influence upon their carnivorous foes throughout the whole long reign of earthly life.

But as in all preceding eras of life, during this age of reptiles their destined successors to dominion were slowly developing, in lowly forms, far below the huge reptilian monarchs. True birds gradually developed, and the flying reptiles disappeared before them. The feather proved superior to the membrane as a flying organ, and in the competition for food which succeeded, the membrane-winged creatures vanished. At a later period other membrane flyers, of mammalian organization, came into competition with the feathered tribe. But they have failed to dispossess them. The bats have been restricted to a nocturnal life, and the birds still hold the diurnal empire of the air.

Such was not the case with the mammalian occupants of the other two fields of life, the land and the sea. Before their onset the wave of reptilian life rapidly sunk, and that of mammalian life as rapidly rose. This advance of the Mammalia to supremacy seems to have been a slow one, and was probably hotly contested by the strongly-armed, swift-moving and huge-sized reptiles. But as in all cases, a superior organization eventually won the battle. The earliest mammals were of the lowly-organized marsupial type. They seem to have been incompetent to cope with the powerful and vigorous reptiles, and after their first appearance, vanish from sight throughout the long period of the Cretaceous era. They probably continued too insignificant to leave any strongly declared marks of their existence in the rocks.

Just how or when the placental mammals appeared, we are ignorant. But their unquestionable superiority to the reptiles in

organization quickly made itself manifest. The reptiles sunk and the mammals rose to the supremacy with such seeming suddenness that it appears almost the work of miracle. Of the hard battle for empire which must have taken place, not a trace remains. We step from the Cretaceous to the Eocene era, and at once we pass from a world ruled by huge reptiles into one controlled by equally huge mammals. The wave of reptilian life rapidly declined, while that of mammalian life broke over it. The former imperial rulers of land and sea sunk into lowly creeping and lurking forms, while the new lords of life grew into swimming and stalking monsters of unquestioned superiority.

It is not probable that this change took place as the consequence of an actual battle between reptiles and mammals. More likely it resulted from a sharp competition for food, in which the mammals gained the victory, the more specialized great reptiles dying out through starvation, while the generalized forms decreased rapidly in bulk and gained new habits.

In regard to this superiority of mammals over reptiles one of its most important features was the hot-blooded organization of the former as compared with the cold-blooded condition of the latter. The result of this condition was to make the reptiles essentially tropical in habitat. Such forms as ventured into colder regions must have hibernated in the winter, and thus could not well have attained any extreme bulk. Hibernation was not necessary to mammals. This fact at once gave them a superiority in colder climates, in which they could develop unopposed, and from which they could descend to the tropics in bulky and vigorous forms to compete with their reptilian predecessors for the food supply.

As for the oceanic mammals, it is not impossible that they also gained their early development in colder regions, which many of them continue to inhabit, and thence pressed southward to compete with the great ocean reptiles. The huge toothed whales of the early mammalian period, typified by the gigantic Zeuglodon, probably were particularly well adapted to obtain food, and may have rapidly swept away the food supply of their predecessors. In this connection there is one point of the greatest importance, to which we have as yet made no allusion, though it doubtless was strongly influential in causing sudden replacements of old by new forms of life. If the competition between old and new types

was less one of personal battle than of success in obtaining food from a common source, then it does not appear at first sight evident why the different dominant types should not have overlapped, the great reptiles, for instance, continuing into the Eocene instead of completely abandoning the field to the mammals.

There is a probable cause of this, to which no attention has hitherto been called, yet which may have been amply sufficient in all such cases. Thus the great carnivorous oceanic reptiles pursued prey which they must have found continually greater difficulty in capturing. The easily taken forms either vanished or changed in organization and habits, growing smaller, swifter, and more wary. They also became continually better adapted to the modes of attack of their foes, so that the difficulty of the latter in obtaining sufficient food for their needs must have steadily increased, and a retrograde movement in size and numbers have arisen. Under such circumstances a new-comer, which had attained size and strength in another region, must have possessed a peculiar advantage. The swimming food had learned the art of self defence or escape from its older foes, but lay helpless before this new foe, to whose mode of attack it was not accustomed. Such a new-comer would therefore be able to make fierce havoc in the ranks of the food animals, and rapidly cut down the harvest. It would tend to a rapid increase in bulk and strength, while its older competitors must shrink in size or perish, starved out of existence. Even when otherwise equal in organization the new-comer would have an immense advantage in the lack of adaptation of the food to its weapons and methods of assault. It is perhaps largely due to this cause that sudden successions in reptilian forms, and in the dominant forms of other types, took place. New forms came from distant regions and robbed the indigenous forms of the bulk of the food. But when to this advantage was added that of a superior organization, as of reptiles over batrachians and of mammals over reptiles, the earlier forms would be supplanted yet more rapidly and completely, and changes in the dominant forms of great suddenness might take place.

To this cause of the numerous apparently sudden replacements of old forms by newer, unrelated forms in geological times, may be added another, which refers to a similar rapid replacement of related forms. The case so far described is that in which a dom-

inant form of animals was replaced by another form of different type which had been slowly growing up beneath it, or more probably had migrated from another locality into one whose food animals were helpless before its assault. But there is another case of extreme importance, that of the apparently sudden replacement of one species by another of the same genus or family, usually of superior organization, with no trace of steps of succession from the one form to the other. This absence of link-forms between closely related species is one of the most marked characteristics of palæontological evidence, and seems to strongly hint at specific succession by leaps instead of by minute steps. Yet the question of food supply yields one argument in favor of the latter which may be here given.

A replacement of one species by another indicates that the second is in some way better adapted to the existing conditions of nature, or to new ones which have arisen. In other words, it is suited to obtain more food with equal exertion, or equal food with less exertion. But the competition which arises is stronger and closer between the offspring and the parental form than between diverse forms. The two related forms are adapted to the same kinds of food, and are closely similar in weapons and habits. Hence of all forms of animal life the one which is put most at disadvantage by the food taking ability of a new form is its parental form. Other tribes of different organization and habits come less into competition with it, or at less disadvantage. If adapted to an entirely different food there is no competition.

Thus two important results are likely to spring from the evolution of a new animal form, specially well adapted to the food conditions of surrounding nature, or possessed of a variety of weapon or habit of assault to which the food has gained no defensive adaptation. One of these results must be the rapid disappearance of the parental form, which will be starved out of existence. And if there be several successive link-forms, each must rapidly yield to its successor. Thus if a considerable or rapid change of natural conditions necessitates a similar rapid succession of specific variations in some animal tribe, not only the original form would vanish, but the link forms would quickly disappear. The new dominant form would tread down its steps of advancement, and the intermediate forms, having a comparatively short term of existence, and giving rise to comparatively few in-

dividuals, would be very unlikely to leave a geological record of their existence. This perhaps is one important cause of that marked absence of link-forms between related species which has given rise to so much controversy.

The effect of this influence upon animals of different type, but subsisting on similar food, would probably be of a different character. While acting to crowd out older forms it might also instigate specific variation, and the evolution of new organs and habits. Thus progress in any one type might powerfully tend to cause progress in other types, and new species evolve simultaneously in several unrelated types, through the action of a single initial force.

As to the succession of huge Mammalia in the Tertiary age, little need be said beyond the considerations already taken. One important fact appears, that the greater land Mammalia were Herbivora, a fact in opposition to that which appears in the case of air and ocean animals, in which elements the Carnivora have always held the supremacy in size. The reason for this we have considered in the case of the birds. As for the ocean animals it naturally arises from the fact that in the ocean animal food is far more abundant and nutritious than vegetable. On the land the opposite conditions rule. Vegetable food is more abundant, while animal food can only be obtained with greater exertion than is required in the water. Hence we find the land Herbivora steadily tending to exceed the Carnivora in size. This is not the case with those timid Herbivora which seek safety in flight, and thus exhaust tissue by great muscular effort. But as soon as a grass or leaf-eating animal grew strong and bold enough to resist and fight off carnivorous foes, the diminished exertion required and the greater time for nutrition, enabled it to increase in size and to quickly grow too powerful to dread the strongest Carnivora.

This result we find occasionally even among the ordinarily timid deer, as in their extinct relative, the gigantic Sivatherium. Of the other huge forms it will suffice to mention the mighty stalking Dinosauria of the reptilian age, whose biped attitude must have aided them to a superabundant supply of leaf food; and the elephantoid mammalian type whose superior organization enabled them to persistently survive and to evolve successively better adapted forms, while other types swelled into hugeness shrank again and disappeared beside them.

We cannot undertake here to consider the various huge creatures which successively appeared and vanished, with the probable cause of their success. It is simply our purpose to generally illustrate the principles of growth already reviewed. A brief reference to the vegetable kingdom, however, is here of some importance. In this kingdom nutriment is not consumed in producing muscular, nervous or temperature vigor, and reproductive energy alone competes with growth vigor. In vegetables, as in animals, those that employ most nutriment in reproduction attain the least size. The trees which bear juicy fruits, and which thus lay up a large stock of protoplasm for the use of their offspring, are smaller and shorter lived than the nut-bearing, and these again than the seed-bearing.

Also in vegetables as in animals the size is greatly affected by the degree of efficiency in food-taking, and by the character of the embryological development. The spore-bearing plants, the ferns, mosses, &c., yield cases of larval birth. The young needs to pass through a phase of metamorphosis which consumes much of its initial growth energy. Other facts in this connection are the following: Plants which are prevented from seeding are longer lived and grow to greater bulk. On the contrary, those which flower early die young, and the cultivation of fruit trees for early and extreme bearing shortens their lives.

Again, plants of imperfect organization often attain great size in situations of high temperature, abundant nutrition and decreased reproduction. Such is the case with the tree ferns of the tropics, and such was the case with the many huge plant forms of low organization in the Carboniferous age of geology. In this respect plants present phenomena somewhat parallel with those of animal life. With the appearance of the exogens began a retreat of the endogens and the lower forms. While palms, ferns and other low forms have been able to hold their own in the tropics, the exogenous trees have gained the supremacy in colder climates. In these regions the competition for food has been decidedly in favor of the exogens, the endogens have sunk into the lowly grasses, and the ferns into feeble inmates of damp situations. Even the more hardy conifers have been driven back before the march of the exogens, and have retreated to the marshes and the cold and partly barren mountain sides, where the character of their organization seems to give them an advan-

tage over their rivals. The nutritive superiority of exogens over endogens and ferns probably arises from their habit of laying up each year an excess stock of nutriment for employment in the early periods of the succeeding year. This relieves them from the necessity of bearing their heavy covering of leaves throughout the storms of winter, and gives them a decided advantage in cold climates over evergreen plants. As for the conifers, they have reduced their leaves to needles, probably for protection against the destructive action of winter storms.

We have one other matter to consider in conclusion. One of the most striking phenomena of palæontological history is the disappearance of most of the great Herbivora and Carnivora with the advent of the Quaternary epoch. Such has not been the case in the air and the water. The whale and the condor have probably never been surpassed in size in their respective fields. Significantly this disappearance on land is closely related to the coming of man. It might appear as if man, with his superior weapons and powers, had been the moving force in this phenomenon. Yet such can hardly have been the case. Man did not come into destructive competition for food with these larger animals, and not at all with the grass and leaf-eating tribes. He may have slaughtered many, both of the Herbivora and the Carnivora, yet he could hardly, in his early days, have greatly diminished their numbers in this manner. For the changes which took place other causes must be sought, and probably the most vigorous of these was the radical changes in climate which took place at this period. Many of the greater animals, incited perhaps by the existence of partly tropical conditions in the temperate regions, had made their way far to the north. On these came down the chill of the glacial epoch, whose influence must have made itself felt even throughout the tropics, and which caused a general change of condition that must have been greatly destructive of animal life, and particularly of the bulkier and more sluggish forms.

After the icy period passed and genial conditions again appeared, the land animals were found to have markedly decreased in bulk. The present elephant succeeded to the gigantic mastodons and mammoths as the greatest of the land animal kind. And with it man had fully disseminated himself over the earth, a new dominant form whose advent put a final and decided check

to the development of any new herbivorous monster. Man needs the earth for himself; he demands the bulk of the food; and the older dominant forms of the lower kingdom of animals are steadily declining and disappearing before his destructive vigor and successful food competition.

Some remarks in regard to the size of man are pertinent in conclusion. The human type, if derived from the Quadrumana, has, like several other animal tribes whose fossil progenitors have recently been discovered, steadily increased in size. The lower Quadrumana are arboreal in habit, and are necessarily restricted in size by the exigencies of their active life. Those which have left the trees for the earth have diverged in two directions, towards the essentially quadruped baboon, and the nearly biped anthropomorphic ape. To the latter the human biped is most nearly related. But the superior organization and powers of man have not resulted in an increase in bulk over the great apes. There has been rather a diminution. And this may have arisen from the great muscular activity and mental energy of man, necessitated in his migratory outspreading over the earth, and his incessant conflict with the lower animals, to which the tropical forest life of the modern great apes makes no demand.

If we consider man in his civilized state no lack of activity appears. The muscular is merely replaced in great measure by active mental energy. Food has grown abundant, but is not superabundant with the great mass of the people of any nation. The share of food obtained by the active farmer, for instance, is much less than that obtained by the sluggish ox in his field. Thus the present average size of man is doubtless partly governed by the average quantity of food which each man can obtain. There is some reason to believe that man to-day is of greater bulk than was the man of the middle ages. The food supply for each man is certainly greater than then. It might be argued that by a decrease in the number of men, under present conditions, an increase in the food supply of each and, therefore, in the average size might be produced, yet any such variation can only take place with extreme slowness. As man now exists his size is in harmonious relation with the conditions of his existence, and cannot be rapidly departed from. In addition to the growth-restraining energies of muscular and mental activity, the reproductive capacity is such that there is a constant tendency to crowd

the field of life and diminish the average supply of food. This is, as yet, obviated by the augmentation of the food supply through human labor, which has, for a long period, caused a steadily increasing ratio of food to consumers. Thus the increase both of leisure and of food supply of civilized man favors an increased growth vigor. If in the future of civilization human fecundity should decrease, as it shows some indications of doing, the size and length of life of man might markedly increase, and the development of the individual gain upon the reproduction of the race.

Hereditary influences act strongly to prevent deviation from any established standard. Yet the leveling effects of heredity are constantly opposed by energies of variation. These seem to be of two kinds, variation by the preservation of minute increments, and by considerable leaps of change. The Darwinian theory of specific variation trusts solely to the former, yet the opposing facts it has to overcome are so many and vigorous, and the palæontological evidence is so strongly in favor of considerable variations, that the idea of leaps from species to species is steadily gaining strength.

The same considerations hold in regard to size variation. It may arise from minute changes, or from the preservation of considerable leaps. Slight variations in size are universal, but leaps to giant or dwarf individuals are not uncommon. With the lower animals it is quite possible that these great variations in size, when in harmony with suddenly changed surrounding conditions, may have been occasionally hereditarily preserved, and rapid growth or diminution in bulk of a tribe of animals have taken place. In man such abnormal variations can scarcely become dominant. Human agency has so succeeded in equalizing the food supply, and in restraining the tendency of outer nature to variation, that conditions vigorously aiding the preservation of a giant or dwarf race are unlikely to arise. The mental force of prejudice is also more strongly active against such a change in man than in the lower animals. Thus human variation in size is more likely to be in accordance with the Darwinian law, of preservation of minute increments of change, in correlation with slowly varying conditions, alike in the food supply, the exertion necessary to obtain it, and the reproductive energy. Giant and dwarf races at present exist in certain regions of the earth, probably produced

in this slow manner, but civilized man everywhere tends to a close conformity in size, as he also does in conditions of existence. Thus any future change in the average size of man must be of very slow evolution. Its direction will probably be towards greater bulk.

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PRELIMINARY NOTE ON SOME FOSSIL FISHES RECENTLY DISCOVERED IN THE SILURIAN ROCKS OF NORTH AMERICA.

BY PROFESSOR E. W. CLAYPOLE.

I.

THE lowest Old Red Sandstone of Scotland, the argillaceous slates of Cornwall and the calcareo-argillaceous beds of Ludlow in England, have furnished the most ancient fossils yet published which can be attributed to the class of fish. The first and second of these horizons are included in the Devonian system, the third, which is also the most ancient, forms the upper part of the Silurian.

Except two species of Onchus (*O. murchisoni* and *O. tenuistriatus*) all these fossils are referred to the abnormal family of Cephalaspids—a family so abnormal that some zoölogists have seriously doubted if its members were really entitled to the name of fishes. But evidence recently obtained has, in the opinion of those who have specially studied them, Professors Huxley and Lankester, satisfactorily settled the question in their favor, and they are now, with general consent, retained among the vertebrates, of which they form the most ancient type hitherto recognized.

Fossil fish have been reported from rocks called Silurian in Bohemia and in Russia, but the genera and species present an aspect so decidedly Devonian, judging by the English strata, that it is not easy to correlate the two. Asterolepis, Gompholepis, Coccosteus and Ctenacanthus can scarcely be paralleled with the more primitive types of the English Ludlow above alluded to.

No species of fish has yet been published from the Silurian rocks of America, or even from the Lowest Devonian. The most ancient fossils of this class which the western continent has yielded have been found in the Corniferous limestone of Ohio and the beds at Campbellton near Gaspé in Canada. Of these the latter is probably rather the older of the two, as it contains